WGCV-53

Terrain Mapping Subgroup (TMSG) status, DEMIX Final Report, & Outlook

Peter Strobl, EC-JRC

Agenda Item 1.9

WGCV-53, Córdoba, Argentina

5th - 8th March 2024

CEOS
Committee on
Earth Observation Satellites

TMSG status

Proceedings of the Terrain Mapping SubGroup (TMSG)

- Re-activated early 2020
- as of Feb 29th 2024:
  - 65 subscriptions (+/-1)
  - 15 countries
  - ~50% with CEOS background
  - ~30% Geomorphometry.org
  - ~25-30 have actively contributed to the intercomparison exercise DEMIX (incl. industry!)
- main (only) activity ~~still is~~ **was** DEMIX
- (hybrid) DEMIX workshop & TMSG plenary ~~scheduled for~~ **held** 12/13 July 2023, supported by ESA

Minor update!

Subscription page: https://ec.europa.eu/eusurvey/runner/WGCV-TMSG_membership

TMSG/DEMIX@Geomorphometry23

- Wednesday 12 July: DEMIX workshop
- Thursday 13 July: TMSG plenary

	CEOS DEMIX
15:00-15:20	**Peter Strobl** – *Overview of the DEMIX Initiative*
15:20-15:40	**Carlos Henrique Grohmann, Carlos López-Vázquez, Peter Guth, Conrad Bielski** – The DEMIX Wine Contest: a summary
15:40-16:00	**Carlos Henrique Grohmann** – *The DEMIX Wine Contest Jupyter notebook*
16:00-16:20	**Peter Guth, Carlos Henrique Grohmann and Sebastiano Trevisani** – *Subjective Criterion for the DEMIX Wine Contest: Hillshade Maps*
16:20-16:40	**Guth, Peter L, Grohmann, Carlos H., Trevisani, Sebastiano, & Bielski, Conrad** – *Going Forward: Extending and Exploiting the DEMIX Database With MICRODEM*
16:40-17:00	**Serge Riazanoff** – *DEMIX SG3 "Platforms & Processing" studi misregistration assessment, use of VHR DEMs to produce Sent*

Time (UTC)	#	Description	
07:00-07:05	1	welcome	
07:05-07:20	2	tour de table (online in alphabetical order)	
07:20-07:25	3	wrap-up and status of activities (DEMIX) 5 min	
07:25-07:40	4	feed-back from the audience, responses from a	
		Potential future activities (working titles):	
07:40-07:55	5a	• DEMIX reloaded: more criteria, more reference tiles, fully in the cloud	tbc
07:55-08:10	5b	• GCPIX: intercomparison of GCP libraries	tbc
08:10-08:25	5c	• GDMIX: spatial matching of global GCPs with (shaded) DEMs	tbc
08:25-08:40	6	Discussion and decision on next steps	all

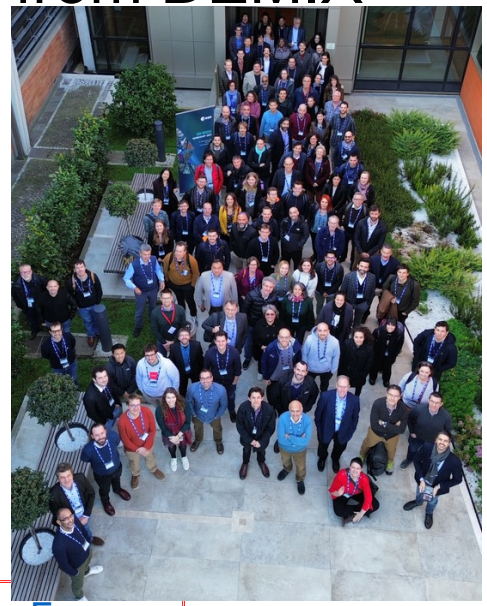
For proceedings see the Geomorphometry23 web page: https://geomorphometry.org/geomorphometry-2023/

TMSG/DEMIX@VH-RODA

15:40 - 17:00		**Digital Elevation Models (DEM)**	**Chair: Peter Strobl (EC-JRC) / Clement Albinet (ESA)**
15:40 - 16:00		Results from the Digital Elevation Model Intercomparison eXercise (DEMIX) Abstract | Presentation	Peter Strobl (EC-JRC)
16:00 - 16:20		Planimetric Misregistration Assessment between DEMs Abstract | Presentation	Serge Riazanoff (Visioterra)

14:00 - 15:20		**Fiducial Reference Measurements (FRM)**	**Chair: Sam Hunt (NPL) / Kevin Alonso (RHEA for ESA)**
15:00 - 15:20		GCPIX: a Proposal to Orchestrate GCP (Ground Control Point) Collection for Global Satellite Earth Observation Abstract | Presentation	Cody Anderson (USGS EROS)/ Peter Strobl (EC-JRC)

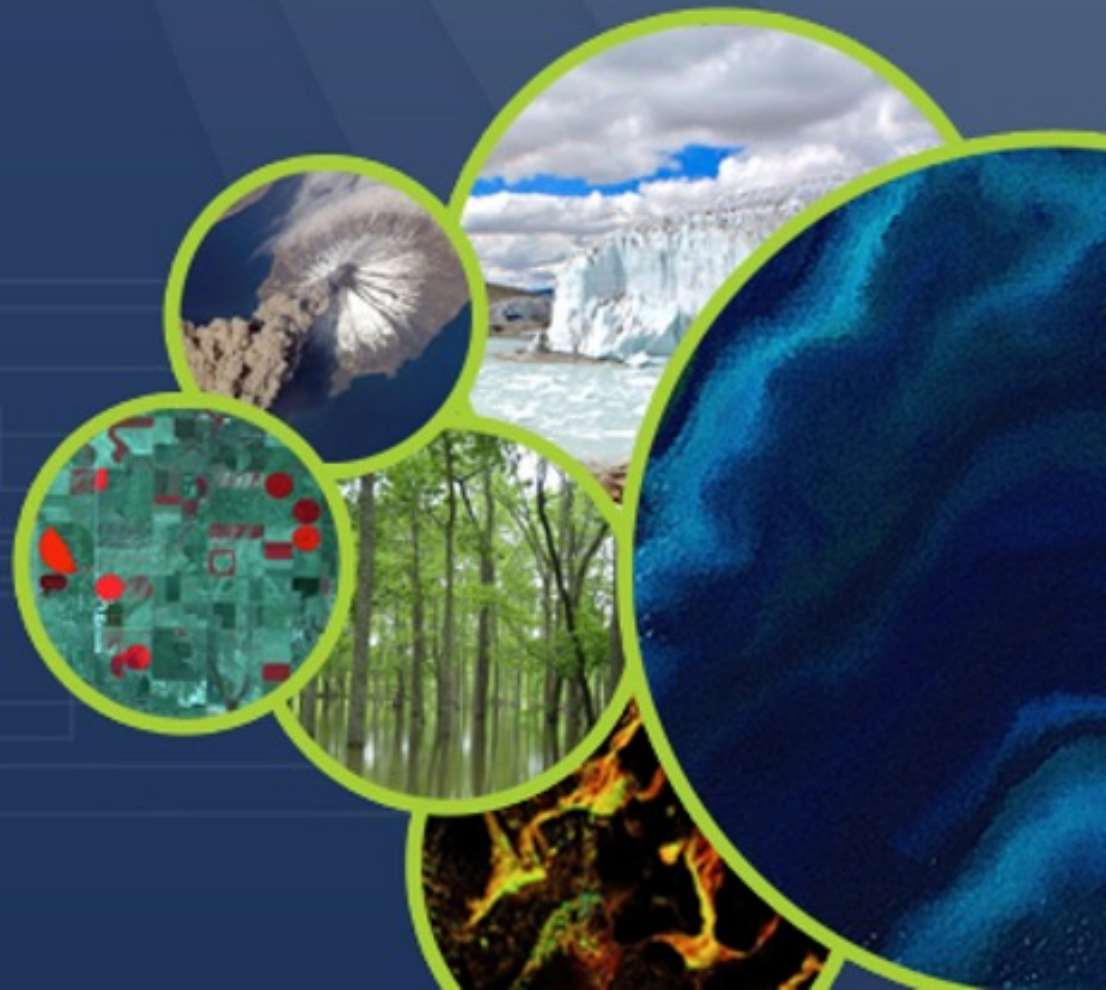
- FRM session on 28/11/2023
  - Presented first concept for GCPIX
- DEM session on 29/11/2023
  - Two contributions from DEMIX



For abstract and presentations see VH-RODA web site: https://earth.esa.int/eogateway/events/vh-roda/agenda#collapseFour

Committee on Earth Observation Satellites

DEMIX Results



DEMIX – the origins

Situation in 2019

Findings of the JRC DEM benchmarking workshop (Jan 2019):

- **new data sets** are coming up (“Copernicus DEM“), which might change the DEM ‘landscape‘
- EO platforms and ‘data cubes’ make data increasingly available also at **continental to global scales**
- literature is rich in **DEM validation and comparisons** of (almost) everything with everything else in many different places
- methodologies vary and results are not always **representative or comparable** between studies and locations

➢ a coordinated approach is desirable!

➢ bring CEOS TMSG and the International Society for Geomorphometry (ISG) together!

DEMIX Scope

CEOS WGCV mandate for DEMIX:

- perform a state-of-the-art comparison of the major global (free&open) DEMs
- provide recommendations on best available DEM options depending on domain and area to allow informed choices

decision in 2020

Expected Outcomes

- Consistent and comprehensive DEM definitions and terminology (t)
- Base (t) and extended (g) set of benchmarking metrics and respective algorithms (t) and open source tools (g)
- Detailed comparison results on test areas (t) and aggregated wall to wall benchmarking results (g)
- Recommendations regarding reference DEMs (t) and consistent orthoimage (g)
- Final report (t) and peer-reviewed publication (g)

(t) threshold; (g) goal

DEMIX outcome

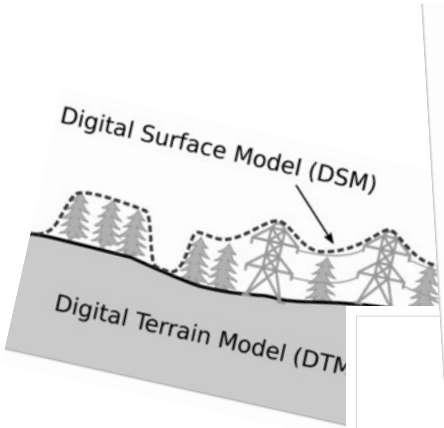
after

- 3 years,
- 3 plenaries,
- Teams groups
- 3 subgroups, each with 5-15 active members,
- 130+ subgroup meetings, each with at least 4 participants
- a conference paper and video,
- 3 peer-reviewed publications,
- a new ‘DEMIX tiling’ system,
- a processing platform, …

we are almost there…

Terminology

Revised terminology and developed comprehensive definitions (glossary)
Peer reviewed paper published,
53 citations as of 02/2024: Guth et. al. 2021

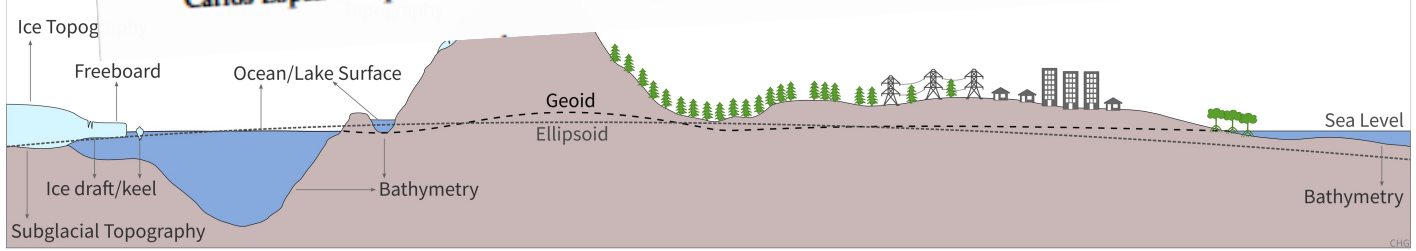


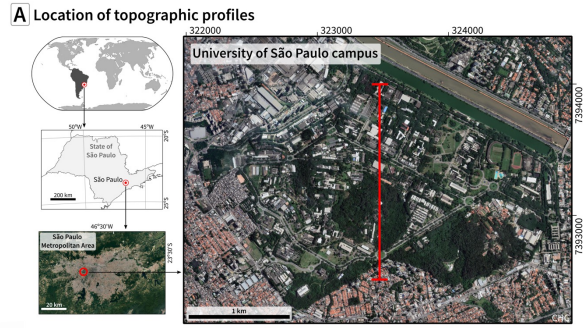
remote sensing https://doi.org/10.3390/rs13183581 MDPI

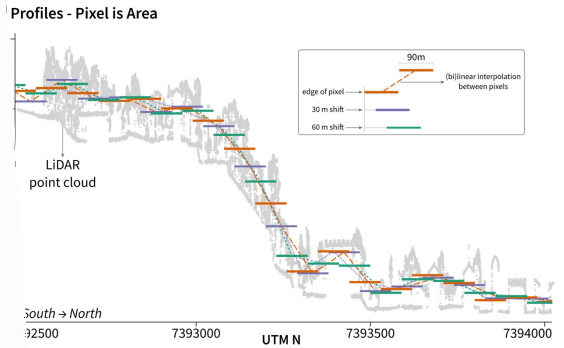
Article

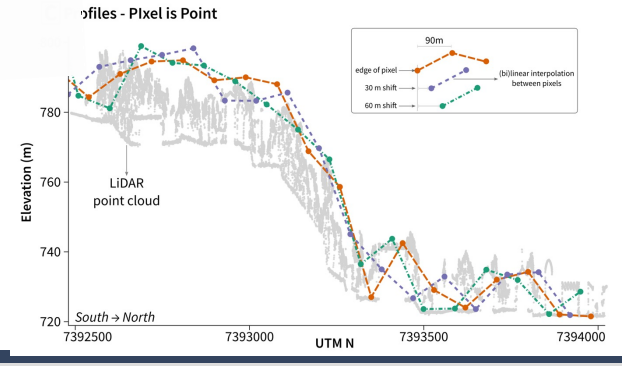
Digital Elevation Models: Terminology and Definitions

Peter L. Guth [1,*], Adriaan Van Niekerk [2], Carlos H. Grohmann [3], Jan-Peter Muller [4], Laurence Hawker [5], Igor V. Florinsky [6], Dean Gesch [7], Hannes I. Reuter [8], Virginia Herrera-Cruz [9], Serge Riazanoff [10], Carlos López-Vázquez [11], Claudia C. Carabajal [12], Clément Albinet [13] and Peter Strobl [14]





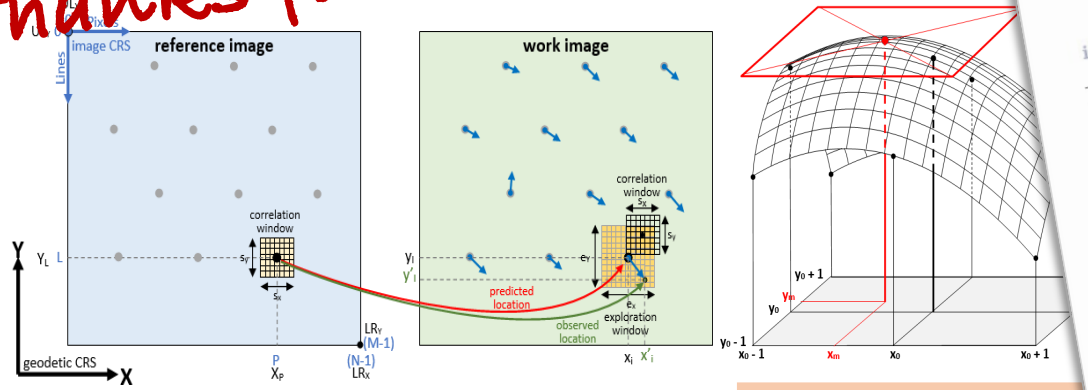




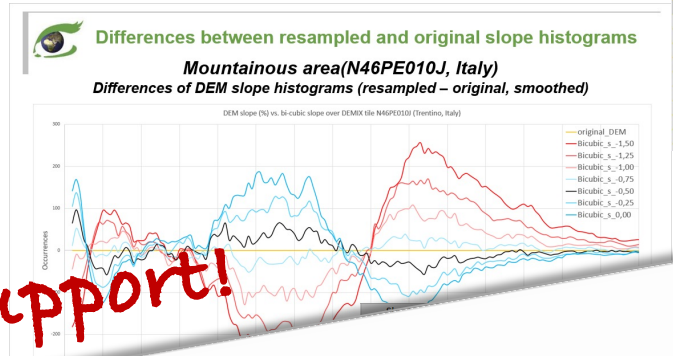
Preparatory and support activities

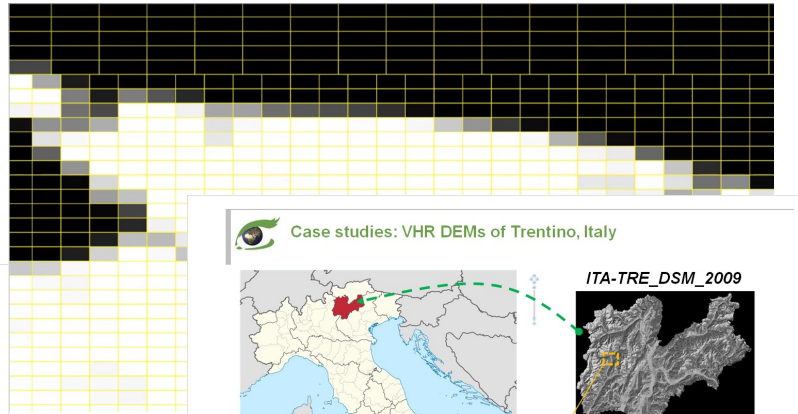
- Global master grid ('DEMIX-tiles') implemented
- Extensive study on influence of resampling on planimetric misregistration
- Reference DEM repository and DEMIX test tile preparation facility

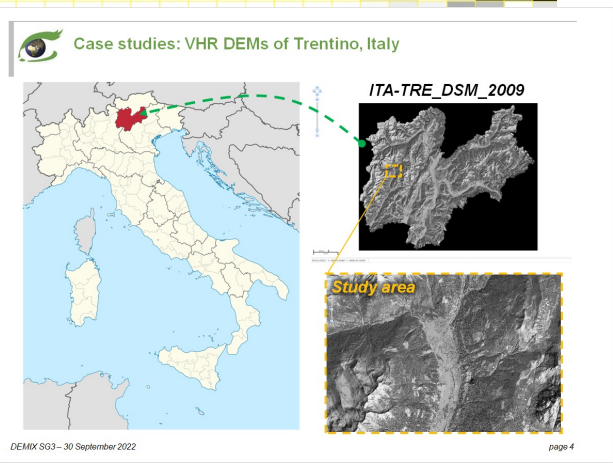
Thanks for vtweb & ESA support!



$r(x,y) = a.x^2 + b.y^2 + c.xy + d.x + e.y + f$

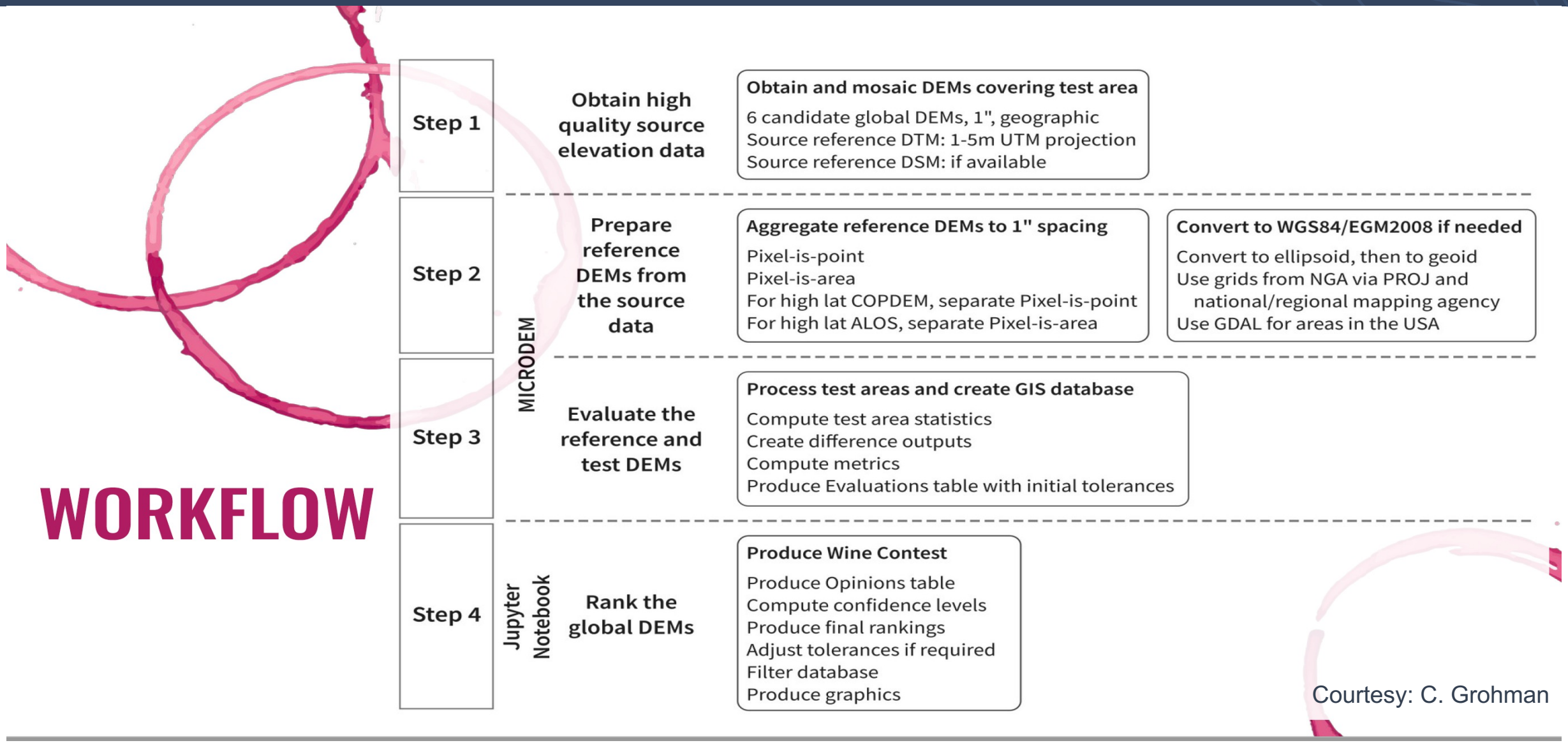






	30 m	DSM	v2.1 (date not found)
rth East of Provincia de Buenos Aires)	depend on tile	DTM	Not found
ts of multiple provinces)	0.5 m	DTM	Not found
s of multiple provinces)	0.5 m	DSM	Not found
	1.5 m	DTM	2021
	1.5 m	DSM	2021
nto)	2 m	DSM	(26.04.2021)
nto)	2 m	DTM	(26.04.2021)
alities of the Rio Doce Basin Committee)	0.5 m (in GeoTIFF)	DSM	(26.05.2021)
ll state)	1 m	DSM	Not found
ll state)	1 m	DTM	Not found
	-	-	(2002)
ce of Trento	1 m (type 1), 2 m (type 2, 3)	DSM	Not found
e of Trento	1 m (type 1), 2 m (type 2, 3)	DTM	Not found
e of Trento (Campolongo only)	1 m	DSM	Not found
of Trento (Campolongo only)	1 m	DTM	Not found
of Trento (without Campolongo)	0.5 m	DBM (DTM + Buildings)	Not found
f Trento (without Campolongo)	0.5 m	DSM	Not found
f Trento (without Campolongo)	0.5 m	DSM	Not found
f Trento (without Campolongo)	0.5 m	DTM	Not found
	1 m	DTM	(17.02.2015)
	1 m	DSM	(17.02.2015)
	1 m	DTM	(2020)
	1 m	DSM	(2020)
	1 m	DSM	(2020)
	10 m	DSM ?	(2007)
	1 m	DTM	25.09.2022
	1 m	DSM	24.09.2022

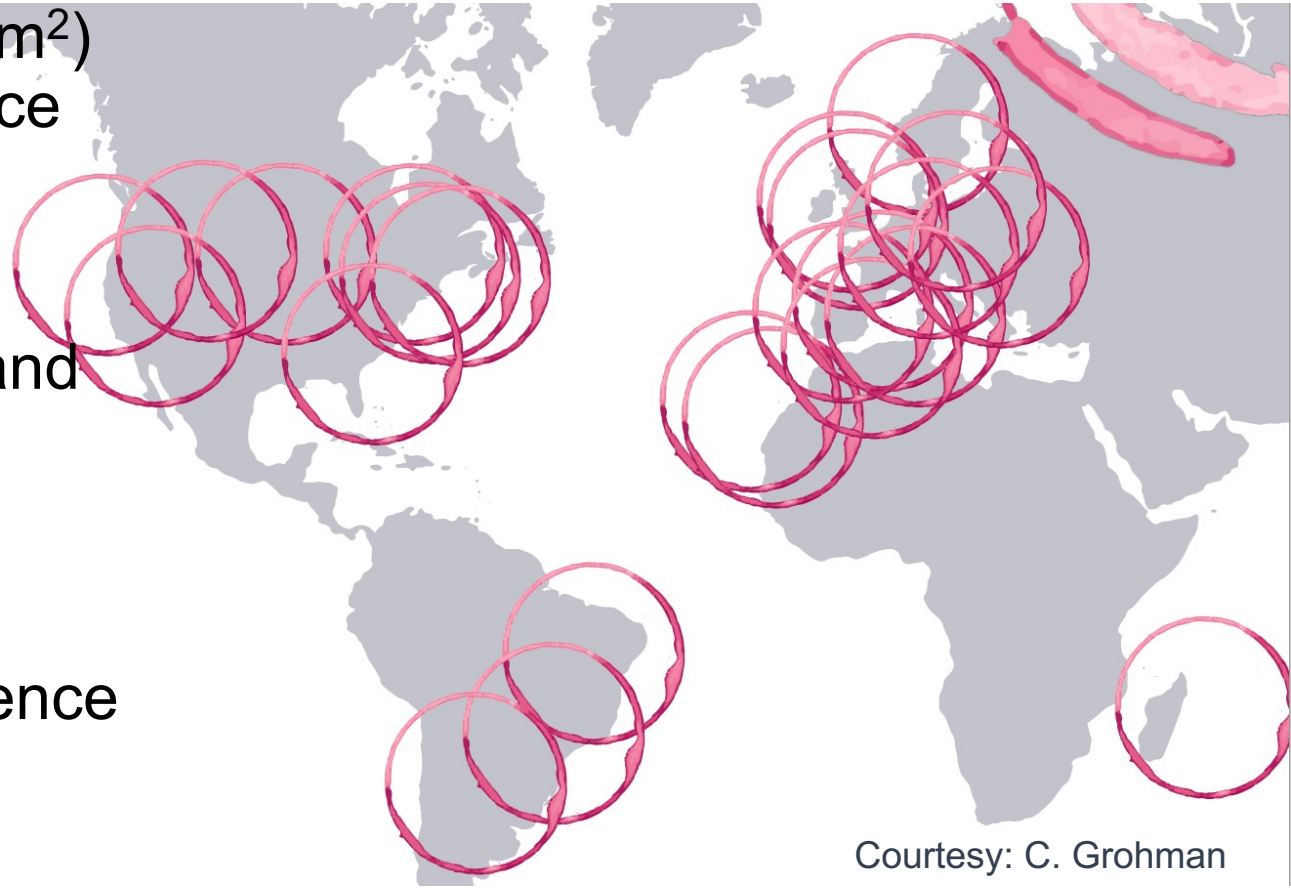
DEMIX ‘wine contest’



Courtesy: C. Grohman

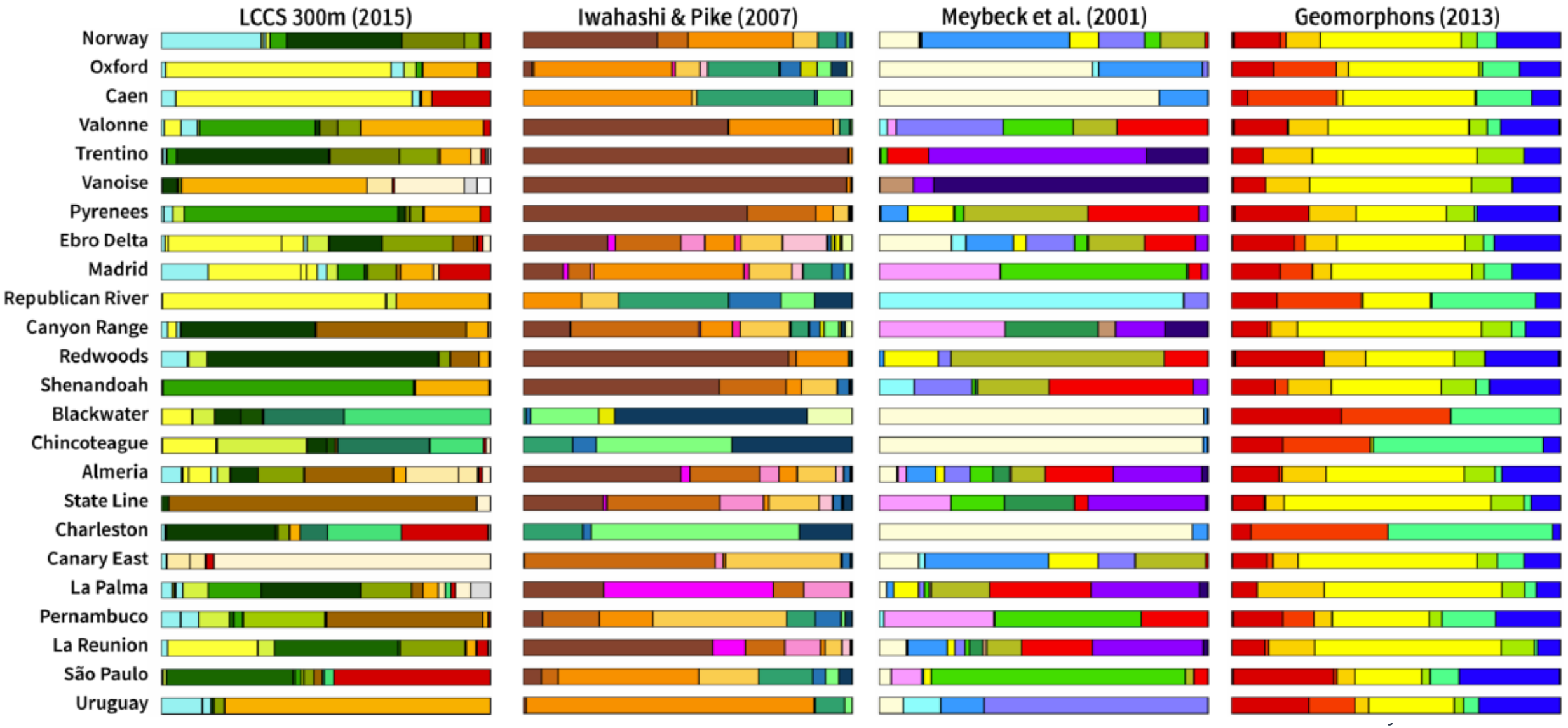
DEMIX test area distribution

- 24 test areas, 236 DEMIX tiles (10x10km^2) on four different continents with reference data
- Reference data preparation tool
- All major geomorphological landforms and landcover types represented incl. coastal areas (partial water)
- 15 different criteria in 3 classes
- Pixel by pixel comparison against reference data
- >55.000 individual test scenarios (rows in opinions database)



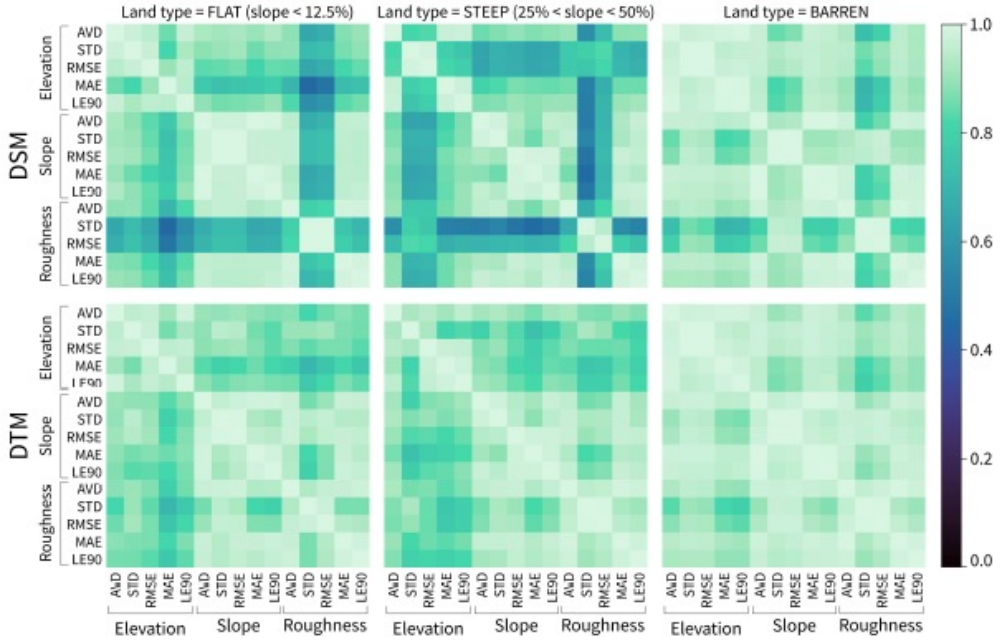
Courtesy: C. Grohman

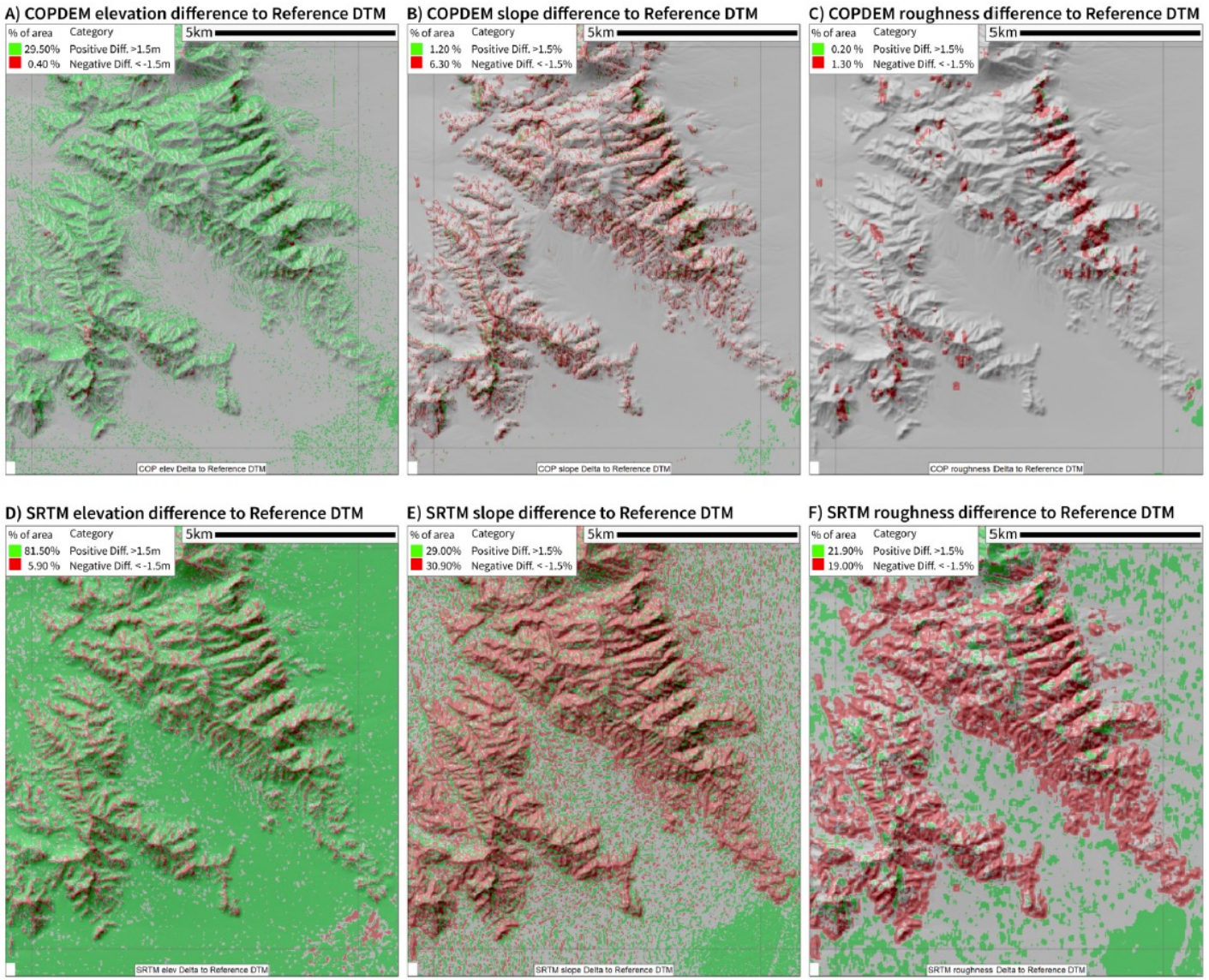
DEMIX test area variability



DEMIX test criteria

- 3 main classes of criteria: elevation, slope, and roughness difference
- 5 different metrics to characterise difference per test area: AVD, STD, RMSE, MAE, LE90





… and the winner is:

AWARDS

COPDEM | Overall best DSM

FABDEM | Best DTM (except for steep terrain)

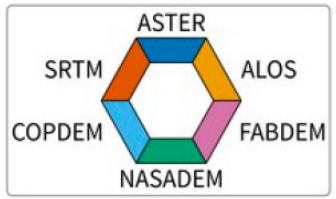
ALOS AW3D30 | Sometimes 2nd place might be better in steep terrain than FABDEM

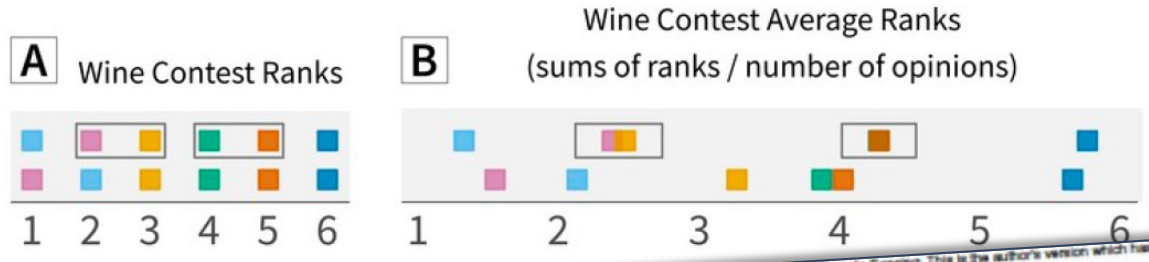
Courtesy: C. Grohman

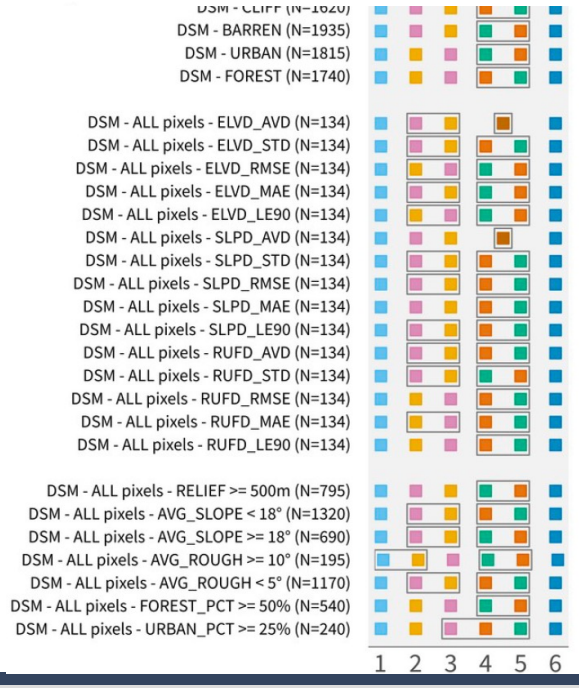
Job done!

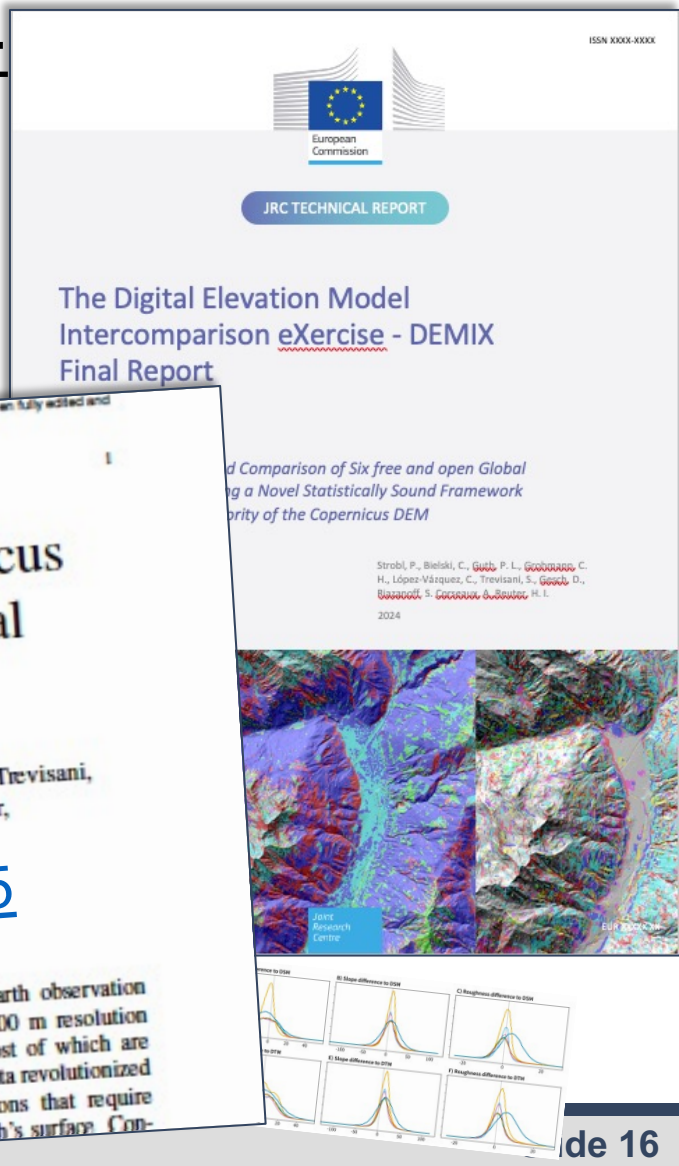
Peer reviewed paper accepted: Bielski et al 2024

Final report close to release (JRC technical report)



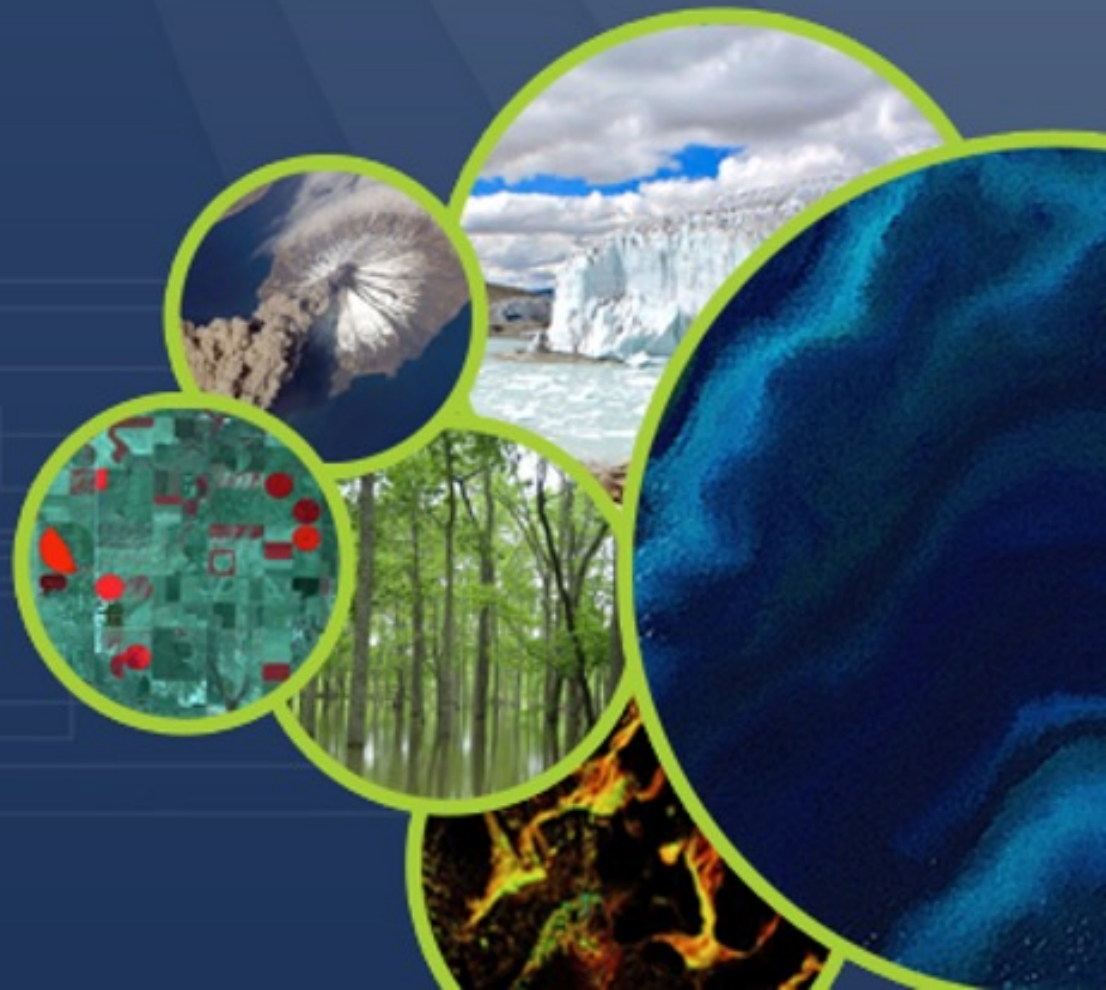






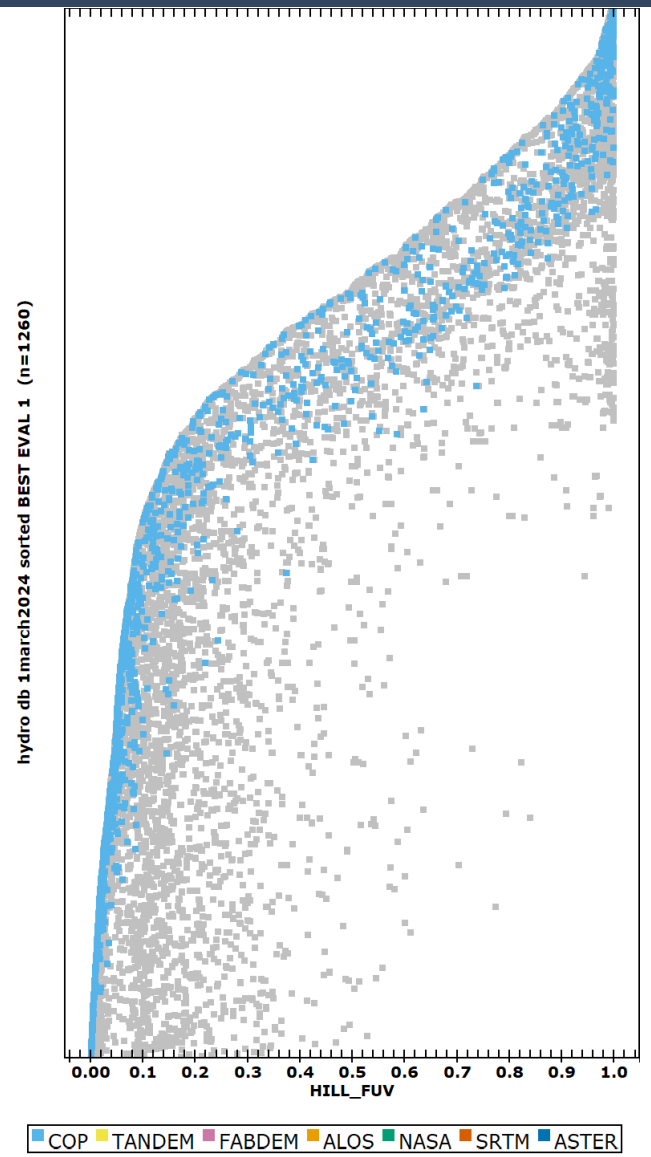
Committee on Earth Observation Satellites

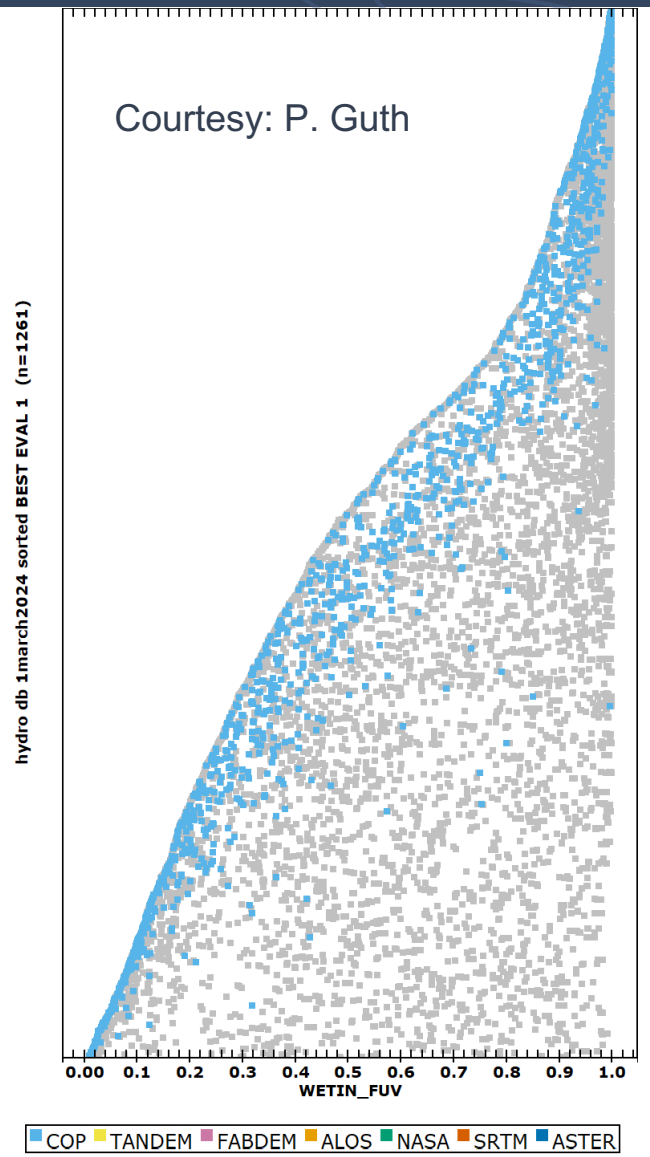
DEMIX Outlook



In the meantime

- Further criteria:
  - Hillshade
  - Wetness index
- New metrics:
  - FUV (fraction unexplained variance, 1-r²)
- More test areas:
  - 107 test areas in the USA, ES, CA, BR, UY, FR, UK, NO, NL, DK
  - 1700+ tiles

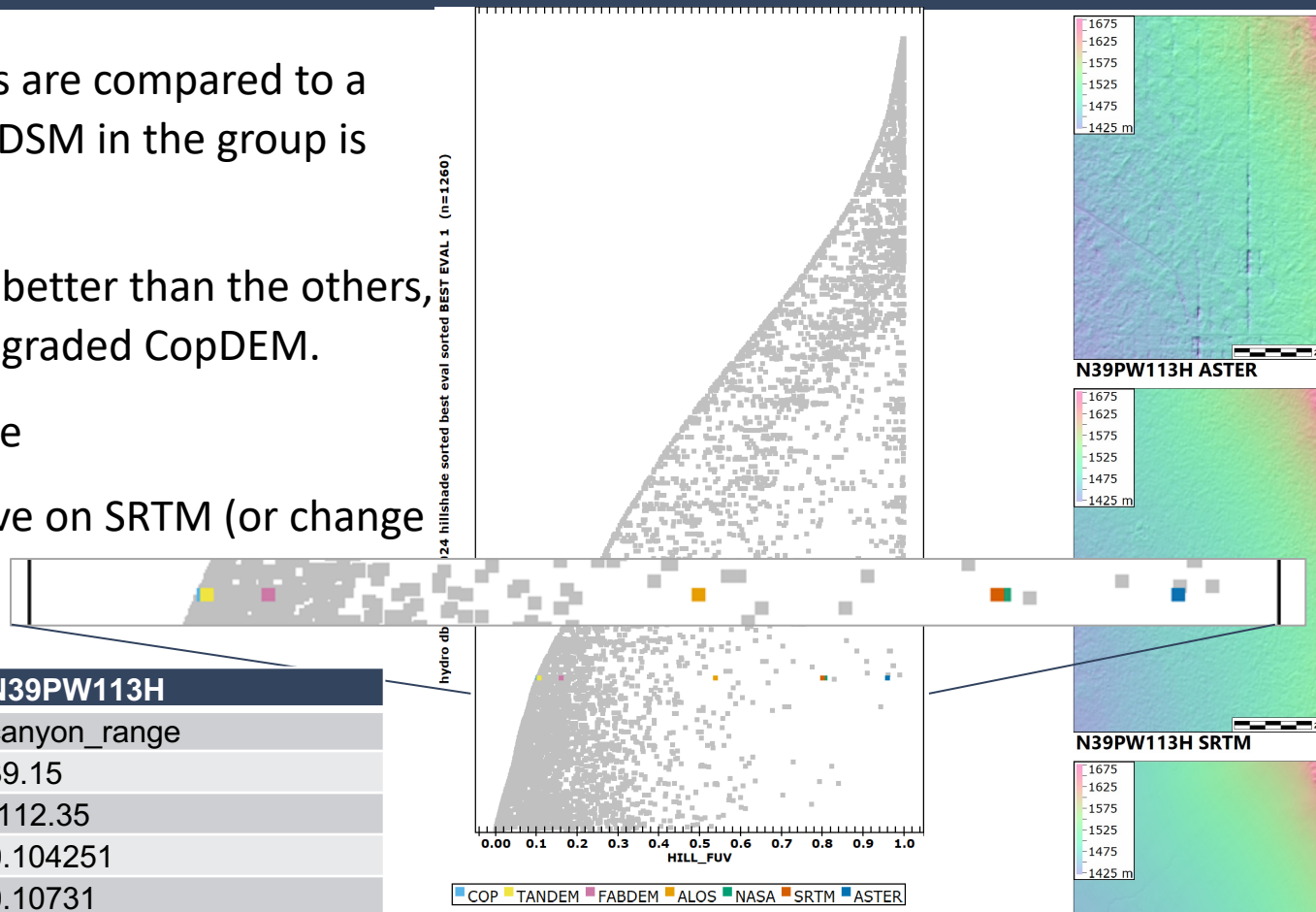




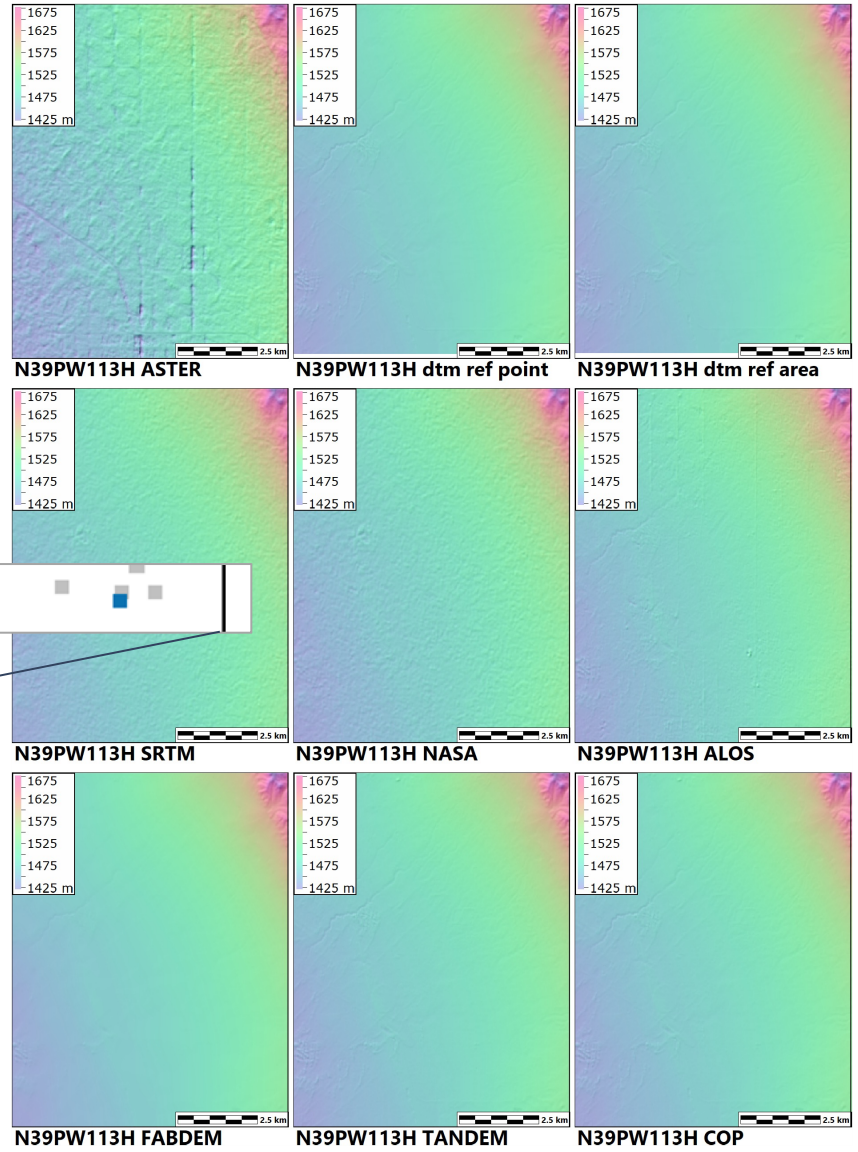
Focus in on single tile

- Even though all the DEMs are compared to a reference DTM, the only DSM in the group is not the best performer.
- CopDEM family is clearly better than the others, although FABDEM has degraded CopDEM.
- ALOS is significantly worse
- NASADEM did not improve on SRTM (or change it much), and neither performs very well
- ASTER fails

DEMIX_TILE	N39PW113H
AREA	canyon_range
LAT	39.15
LONG	-112.35
COP	0.104251
TANDEM	0.10731
FABDEM	0.160949
ALOS	0.539178
NASA	0.806989
SRTM	0.800862
ASTER	0.960294

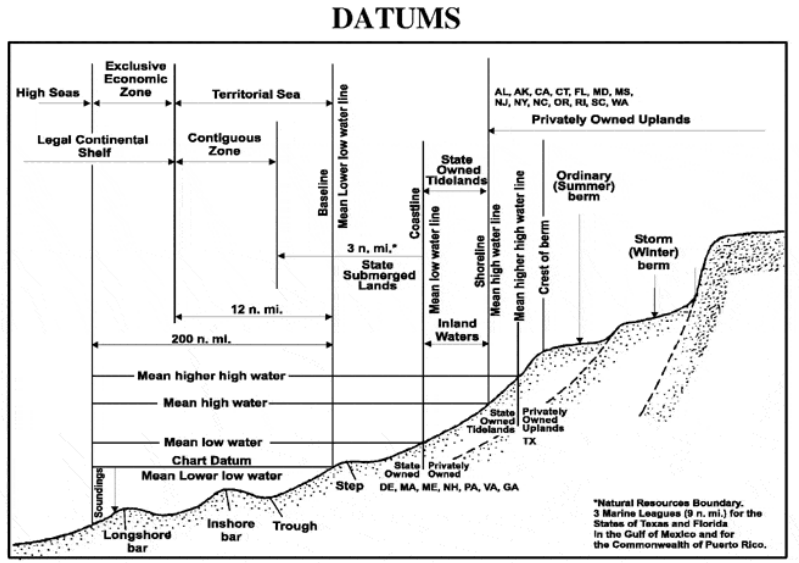


Courtesy: P. Guth



Up to new shores?

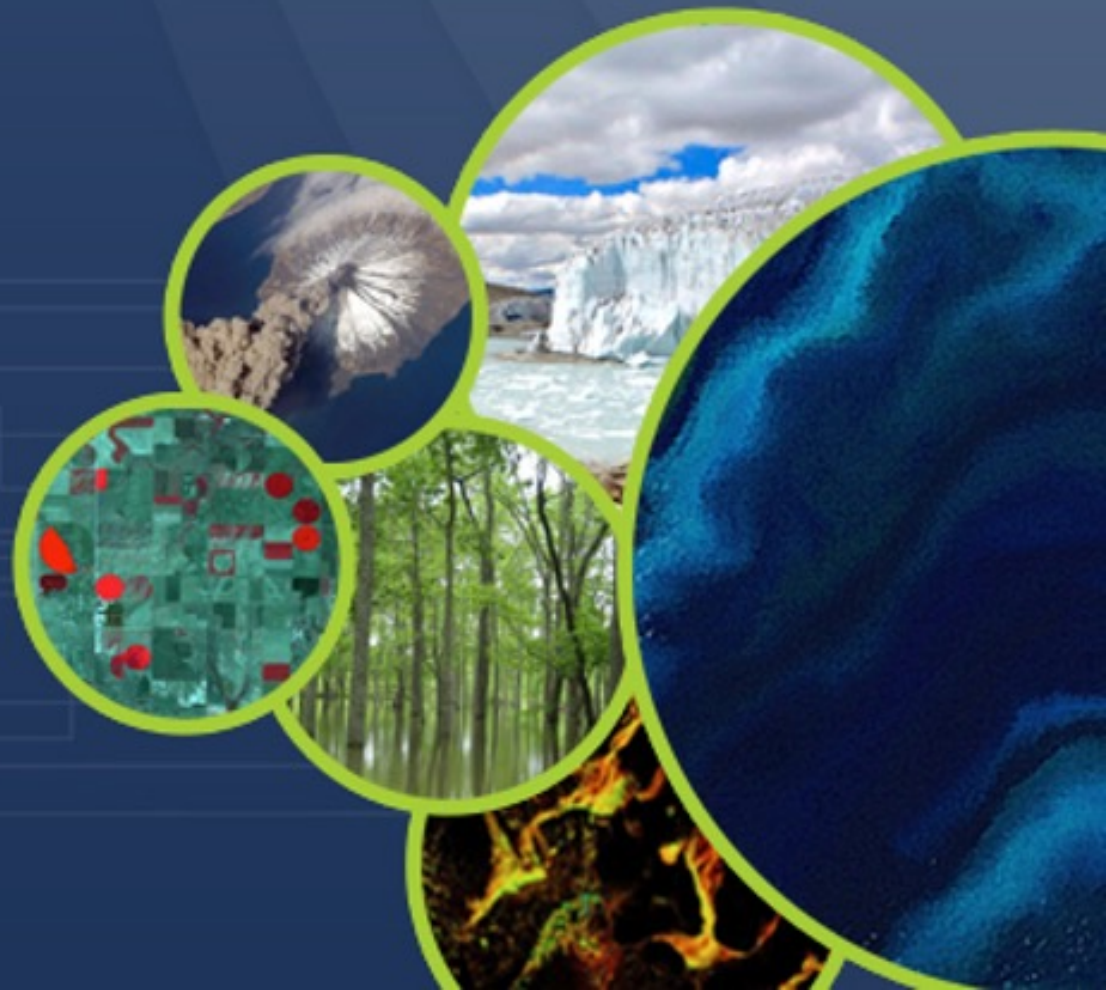
- Coastal areas globally are witness to growing disaster risks.
- The elevation/area around “Coastlines” are the interface between land and water (+/- 10m depth/height)
- Detailed elevation models are required to estimate tide areas (sea level rise), emergency (tsunami), environment (e.g. loss of biodiversity), inhabitants impact (e.g. urban development)
- **Objective: to {create/test} a global coastal elevation dataset/{method}**



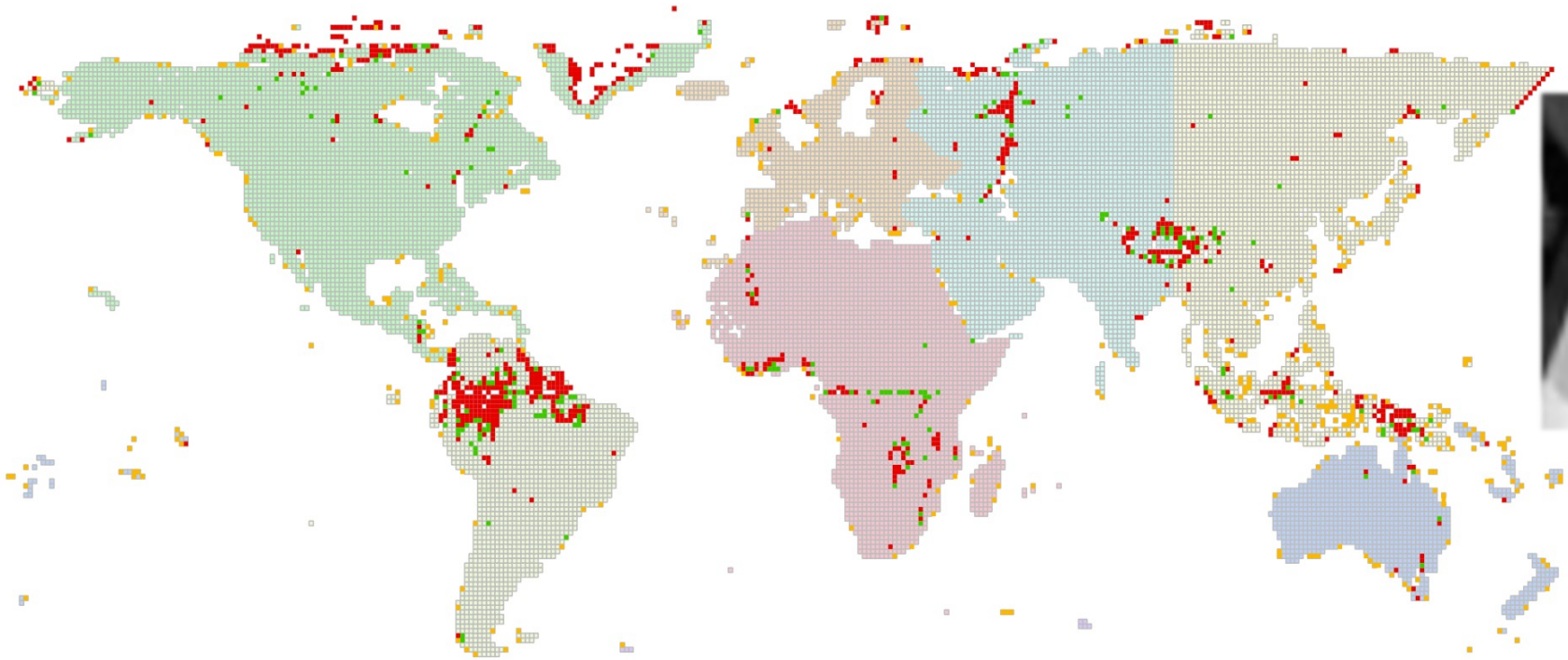
Source: Tidal Datums https://www.oc.nps.edu/nom/day1/tidal_datums_fig17.gif –
Picture: ©AdobeStock- licenced obtained Further Reference: https://www.nature.com/articles/s41558-024-01950-2

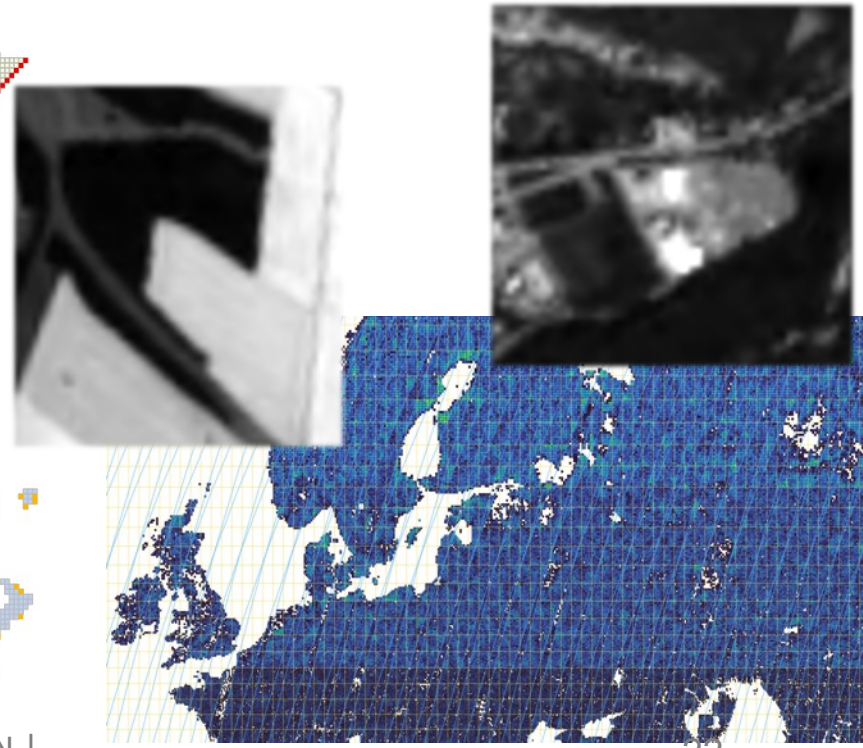
Committee on Earth Observation Satellites

GCPIX Outlook



Community **recommendation** from the key forums **“VH-RODA”** and **“JACIE”**
Build up a **GCP DB for the VHR domain**
CEOS WGCV welcomed and closely followed the **Sentinel-2 Global Reference Image (GRI)** and **harmonization** with **Landsat GCP Library** which can serve as a **reference for high resolution (HR)** sensors (around 10 m – 50m GSD)





***CEOS** is now **proposing** the development of a **harmonised global CEOS Ground Control Points (GCP) Database** and its extension **to cover also VHR Optical Data** [2.5-10m GSD, and **potentially** <2.5m GSD]*

*CEOS agencies are pooling activities and resources towards a unified and **harmonized CEOS GCP Database** for HR&VHR Optical Data*

GCPIX!

*A. Lewis, L.-W. Wang, R. Coghlan, **AGRI: The Australian Geographic Reference Image**, https://cmi.ga.gov.au/sites/default/files/2020-08/agri_report.pdf*

*S. Saunier, S. Kocaman, C. Albinet, P. Goryl, "**Development of a GCP Database Approach for Geometric Cal/Val of VHR Optical Imagery**"*

Check out S. Saunier's poster!

*A. Lewis, I… W. Wang, P. Coghlan. **ACRI: The Australian Geographic Reference Image**. https://ecat.ga.gov.au/sites/default/files/2020-08/agri_re*

Used by th…

License: C…

*National **n…***

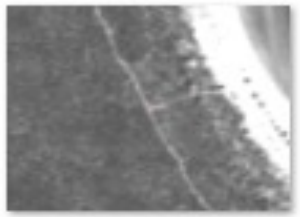
UTM zone…

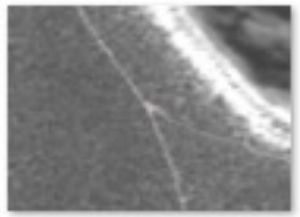
Ground C…

Ground C…

Absolute…

ALOS ima…

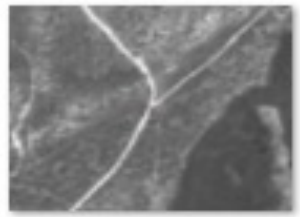

91412002_image_chip.bmp


91412004_image_chip.bmp


91412070_image_chip.bmp


91412078_image_chip.bmp


91412079_image_chip.bmp


91412503_image_chip.bmp


91412002_E_photo.jpg

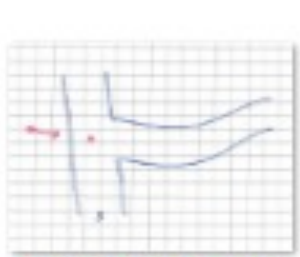

91412004_E_photo.jpg


91412070_W_photo.jpg


91412078_W_photo.jpg

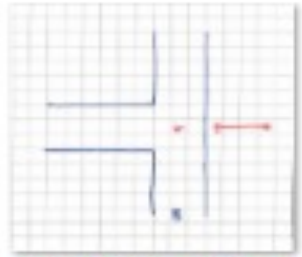

91412079_S_photo.jpg

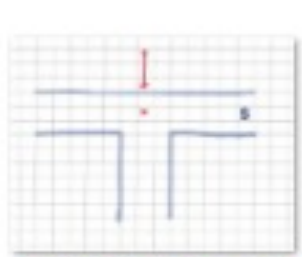

91412503_NE_photo.jpg


91412002_sketch.jpg


91412004_sketch.jpg


91412070_sketch.jpg


91412078_sketch.jpg


91412079_sketch.jpg


91412503_sketch.jpg

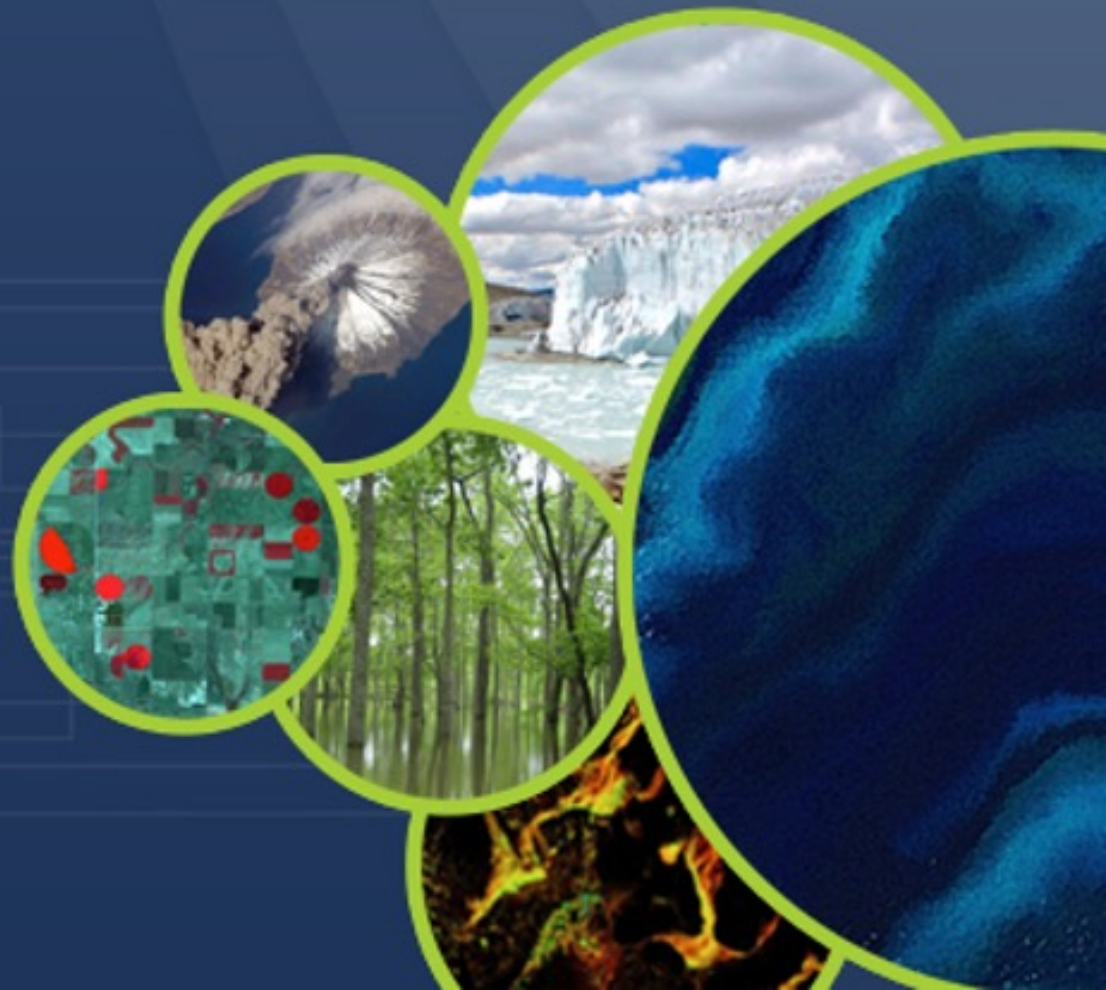
GCPIX – first outline

❖ *Key elements to be further developed during GCPIX*

- define **criteria** for the **suitability** of GCPs (by resolution, season, wavelength, …) and respective uncertainties, spatial density and distribution requirements
- establish **protocols and formats for documenting and sharing** GCPs and respective libraries
- **harmonization** of existing **sources** from the different CEOS agencies **towards a unified DB**
- identification of **gaps/weaknesses** in coverage, consistency, quality, availability, ...
- design and set-up of a (**cloud-based) platform** for sharing and managing the database
- **improvement, densification**, and allocation of **additional source data (VHR)**
- potential inclusion of **DEM data/reference chips** from suitable and agreed reference data

Committee on Earth Observation Satellites

Exkursion:
CEOS Common Terminology



In-situ disambiguation

Location of sample

Location of sensor

Distance sensor to sample

- **In-situ / Ex-situ**
  Observed in its original location vs brought back to laboratory for testing
- **In-situ / satellite**
  Observed e.g. ground-based, sea- or airborne vs from an orbiting platform
- **In-situ / remote**
  Observed close to the location of the sample vs from a (significant) distance

Various communities use the term 'in-situ' in different ways – in contrast to different alternatives.

It is very important to be clear about which notion of ‘in-situ’ is referred to.
Sometimes it relates more to location and sometimes to fidelity.

Paper methodology

- Review of 12 existing vocabularies / terminologies
  - Assessment of useability
  - Identification of circular definitions and inconsistencies
  - Assessment of structure
- Review of ISO guidelines on ‘information and documentation: thesauri and interoperability with other vocabularies) ISO 25964
- Presentations to CEOS, ESA and WMO meetings
- Detailed study of some sample terms
  - Observation, in-situ, interoperability
  - As examples of broader problems
- Building a hierarchical set of base and core terms

Problems found

- Simple lists of words are not used often – structure is important
- Rare to have versioning (or keep older definitions) – and definitions change
- Very large number of definitions for some terms – e.g. in ISO online browsing platform
- Inconsistent definitions (e.g. in-situ, observation, sample, …)
- Superficial definitions (e.g. interoperability) lacking full framework
- Circular definitions – and poor use of the foundational ‘base terms’
- Development process – isolated efforts – creates these problems

Paper

Lost in translation: The need for common vocabularies and an interoperable thesaurus in Earth sciences

P.A. Strobl[1], E.R. Woolliams[2] and K. Molch[3]

[1]JRC, [2]NPL, [3]DLR

- First draft (July 2023) reviewed by 12 expert individuals (thank you)
  - Very significant changes made based on their responses
- Final draft submitted to Surveys in Geophysics (December 2023)
- Currently waiting for peer reviewer comments
- Pre-print available at : (TBC)

Executive Summary

- Completed work to explore a CEOS common online dictionary (CEOS WGCV Action Item 49-06, 06/2021)
- Results summarized in a publication – preprint pending
- Main Findings
  - Large interest in the topic; need, urgency, and effort are recognized
  - Many good but isolated dictionaries exist
  - Critical: Fundamental terms often defined inconsistently
- Implementation needs a coordinated effort endorsed by all stakeholders
- CEOS with its Interoperability Framework could be a suitable body to put this in place

Thank you!

Big thanks to all active volunteers!
In particular the sub-group leaders:
Peter Guth, Carlos Grohman,
Conrad Bielski, Serge Riazanoff,
and Carlos López-Vázquez, the wine contest masterminds!

as well as ESA (Clement Albinet)
and USGS (Dean Gesch)
for their support!

any questions?

Peter.Strobl@ec.europa.eu

CEOS
Committee on
Earth Observation Satellites